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Inoue

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(54) **CONVEYER APPARATUS**

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(51) **Int. Cl.**

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B65H 3/44	(2006.01)
B65H 7/02	(2006.01)
G03G 15/00	(2006.01)
B65H 9/00	(2006.01)

(52) **U.S. Cl.**

CPC .. ***B65H 3/44*** (2013.01); ***B65H 7/02*** (2013.01); ***B65H 9/008*** (2013.01); ***G03G 15/6502*** (2013.01); *B65H 9/006* (2013.01); *B65H 2404/7231* (2013.01); *B65H 2404/7232* (2013.01); *B65H 2511/51* (2013.01); *B65H 2513/108* (2013.01); *B65H 2513/11* (2013.01); *B65H 2513/50* (2013.01); *B65H 2515/322* (2013.01); *B65H 2701/1311* (2013.01); *B65H 2701/1313* (2013.01); *B65H 2801/06* (2013.01)

(58) **Field of Classification Search**

CPC B65H 9/006; B65H 9/008; B65H 2404/7231; B65H 2404/7332

USPC 271/242, 244

See application file for complete search history.

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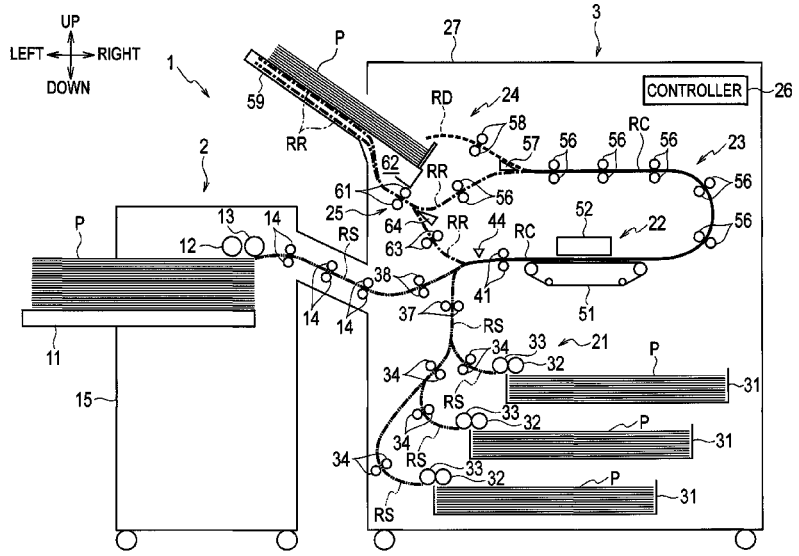
(57) **ABSTRACT**

A conveyance apparatus includes a pair of registration rollers configured to convey a print medium to a printing unit of a printing machine in a conveyance direction, a motor configured to rotate the registration rollers, and a controller configured to control the motor such that after the print medium strikes the registration rollers and thereby forms a predetermined amount of slack in the print medium, the motor starts rotating the registration rollers to convey the print medium, and the motor stops rotating the registration rollers once the print medium exits the registration rollers. In stopping rotating the registration rollers, the controller is configured to drive the motor to generate torque in a reverse rotational direction opposite from a rotational direction in which the motor generates torque to convey the print medium in the conveyance direction.

6 Claims, 5 Drawing Sheets



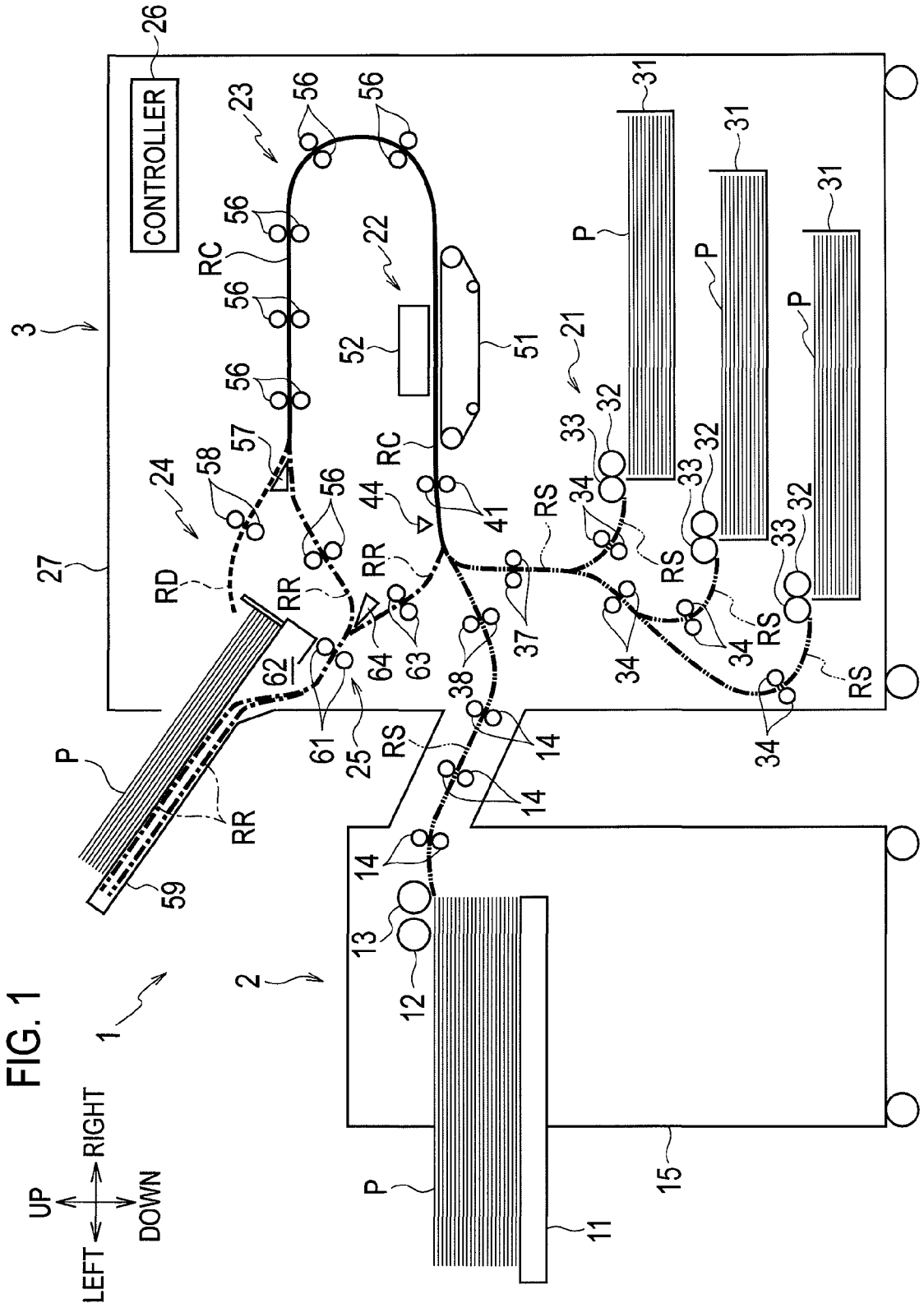

CONTROLLER
26
3
27
1
2
23
22
24
21
51
52
41
44
31
32
33
34
56
57
58
RC
RR
RD
RS
P
59
61
62
63
64
25
37
38
14
13
12
11
15
UP
DOWN
LEFT
RIGHT

FIG. 1

FIG. 2

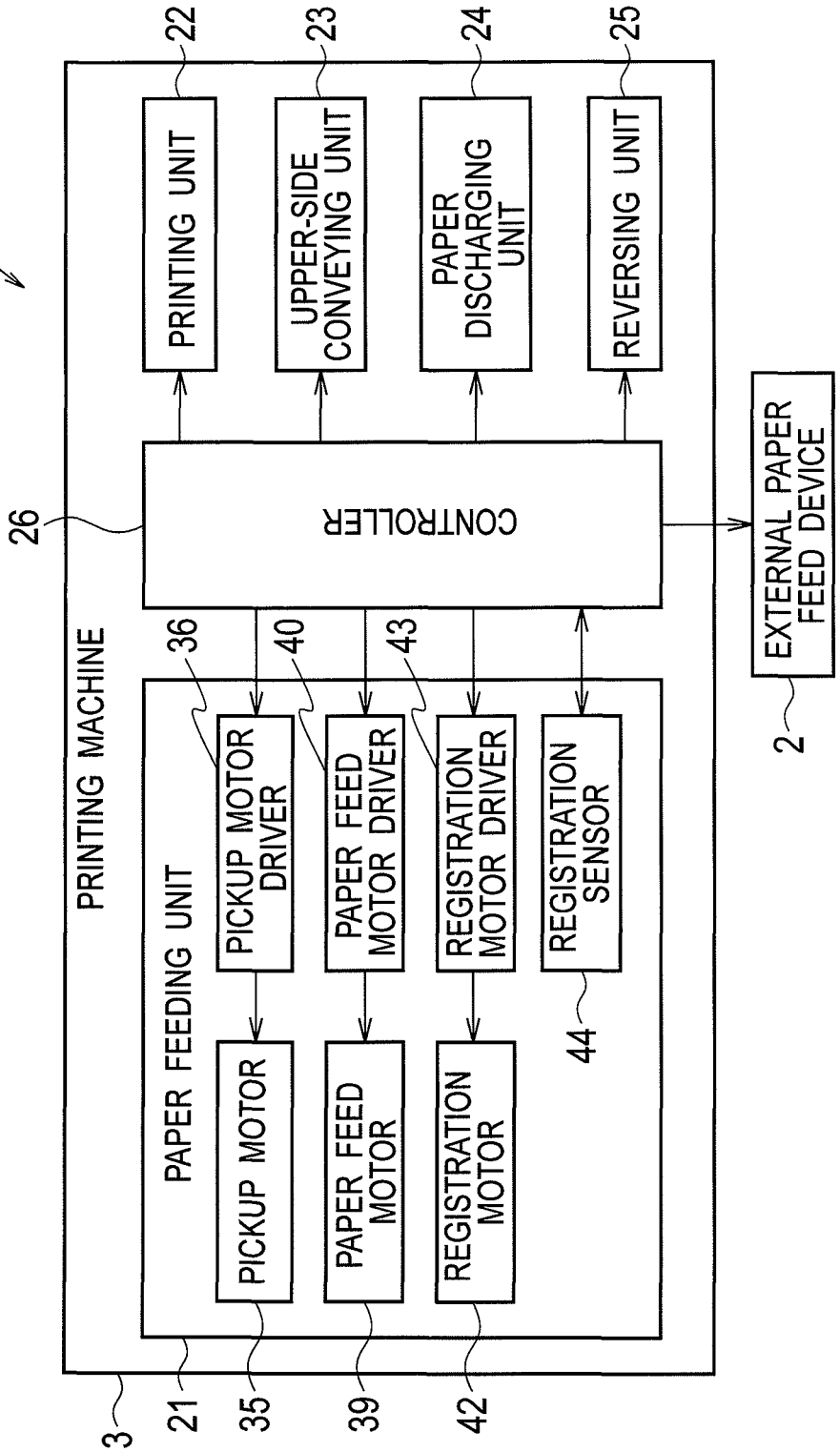

1
22
23
24
25
PRINTING UNIT
UPPER-SIDE CONVEYING UNIT
PAPER DISCHARGING UNIT
REVERSING UNIT
26
CONTROLLER
EXTERNAL PAPER FEED DEVICE
2
PRINTING MACHINE
36
40
43
PAPER FEEDING UNIT
PICKUP MOTOR DRIVER
PAPER FEED MOTOR DRIVER
REGISTRATION MOTOR DRIVER
REGISTRATION SENSOR
44
PICKUP MOTOR
PAPER FEED MOTOR
REGISTRATION MOTOR
3
21
35
39
42

FIG. 3

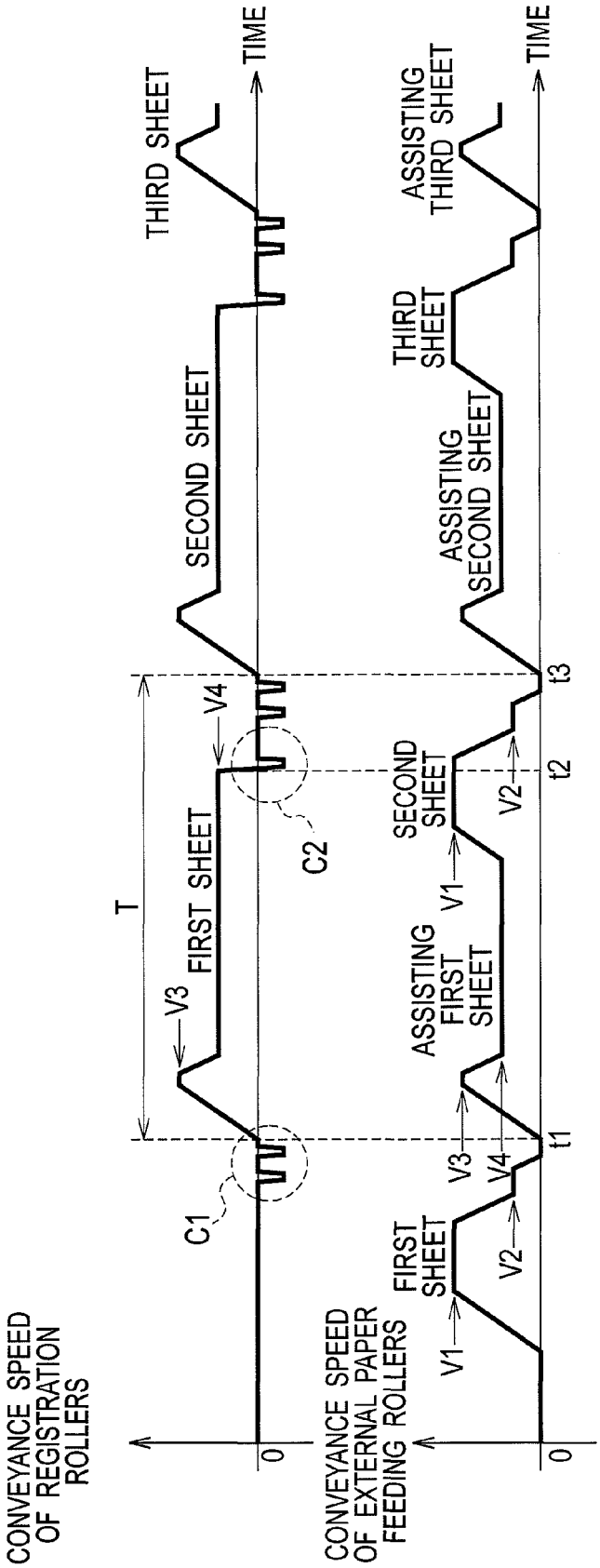

CONVEYANCE SPEED OF REGISTRATION ROLLERS
CONVEYANCE SPEED OF EXTERNAL PAPER FEEDING ROLLERS
TIME
TIME
FIRST SHEET
SECOND SHEET
THIRD SHEET
ASSISTING FIRST SHEET
ASSISTING SECOND SHEET
ASSISTING THIRD SHEET
V1
V2
V3
V4
T
C1
C2
t1
t2
t3
0
0

FIG. 4

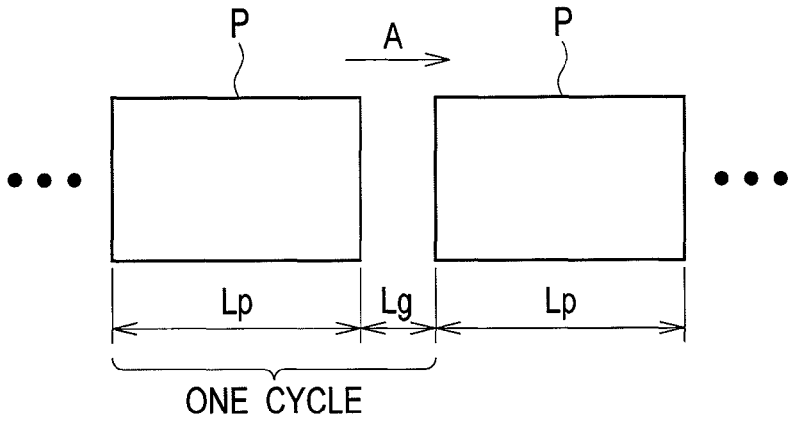

P
A
P
Lp
Lg
Lp
ONE CYCLE

FIG. 5

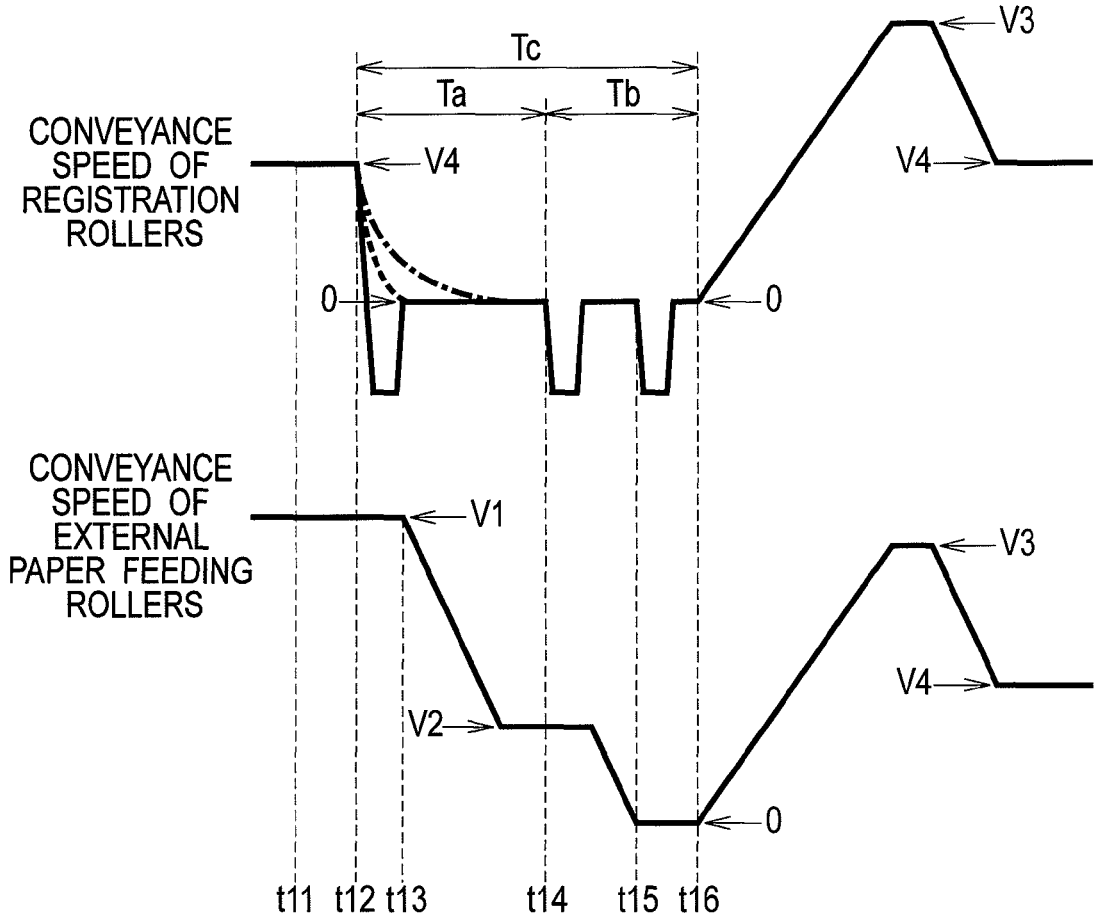

Tc
Ta
Tb
CONVEYANCE SPEED OF REGISTRATION ROLLERS
V4
V3
V4
0
0
CONVEYANCE SPEED OF EXTERNAL PAPER FEEDING ROLLERS
V1
V3
V4
V2
0
t11 t12 t13 t14 t15 t16

FIG. 6A

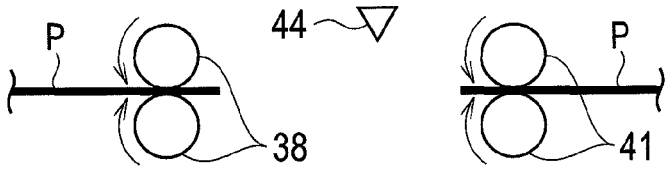


FIG. 6B

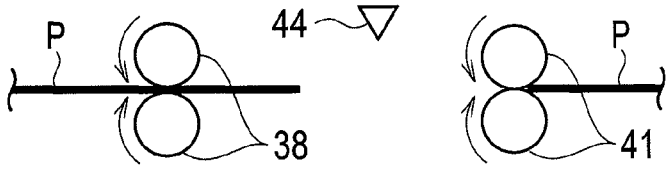


FIG. 6C

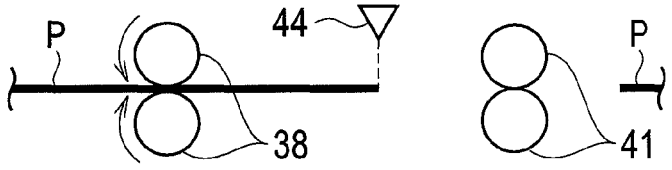


FIG. 6D

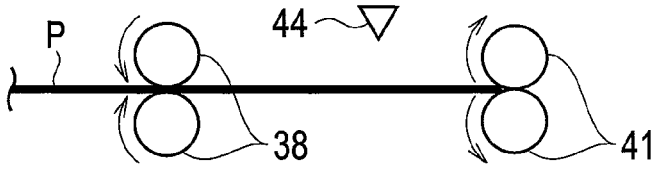


FIG. 6E

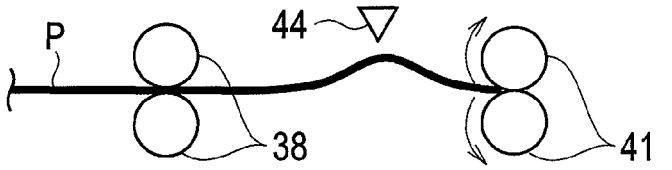
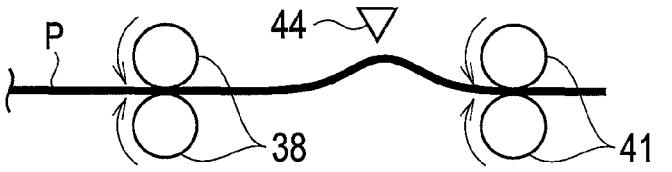


FIG. 6F



CONVEYER APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2012-273023, filed on Dec. 14, 2012, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

The present invention relates to a conveyer apparatus which conveys a print medium such as a sheet of paper.

2. Related Art

Japanese Unexamined Patent Application Publication No. 2010-111472 describes a conveyance mechanism which is employed in a printing machine of inkjet type or the like and configured to feed a sheet toward a printing unit with registration rollers.

In this conveyance mechanism, inclination of a sheet is corrected by striking the sheet against a pair of stopped registration rollers so that the sheet may stop to form slack therein. Thereafter, the registration rollers are driven to feed the sheet to a printing unit. The registration rollers are stopped once the sheet exits the registration rollers.

The registration rollers are stopped by short-circuit brake control. In the short-circuit brake control, terminals of a DC motor for driving the registration rollers are short-circuited.

SUMMARY

The short-circuit brake control requires a certain amount of time from when short-circuit brake is performed to when the registration rollers stop, because of influences, such as inertia and load, of a transmission mechanism from a motor shaft to the registration rollers. Moreover, the time may vary in length.

Thus, if the interval between sheets is small in a case of printing multiple sheets, the leading edge of a succeeding sheet might reach the registration rollers before the registration rollers stop. If a sheet enters the unstopped registration rollers with the sheet being inclined, the sheet is nipped in that state. This may result in failure in correcting the inclination. To avoid this, the sheet interval needs to be set long, but a long sheet interval leads to a decrease in the productivity of the printing machine.

The present invention has an objective of providing a conveyer apparatus capable of improving the productivity a printing machine.

A conveyance apparatus in accordance with some embodiments includes a pair of registration rollers configured to convey a print medium to a printing unit of a printing machine in a conveyance direction, a motor configured to rotate the registration rollers, and a controller configured to control the motor such that after the print medium strikes the registration rollers and thereby forms a predetermined amount of slack in the print medium, the motor starts rotating the registration rollers to convey the print medium, and the motor stops rotating the registration rollers once the print medium exits the registration rollers. In stopping rotating the registration rollers, the controller is configured to drive the motor to generate torque in a reverse rotational direction opposite from a rotational direction in which the motor generates torque to convey the print medium in the conveyance direction.

According to the above configuration, in stopping the registration rollers, the motor generates torque in the reverse rotational direction which is opposite from the rotational direction in which the motor generates torque to convey the print medium in the conveyance direction. This can shorten a time period from a stop-control start timing to when the registration rollers stop. Thus, the interval between sheets in printing multiple sheets can be reduced. As a result, the productivity of the printing machine can be improved.

The controller may be configured to control the motor such that, from a timing when the print medium strikes the registration rollers, the motor temporarily rotates the registration rollers in a reverse rotational direction opposite from a rotational direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction.

According to the above configuration, from a timing when the print medium strikes the registration rollers, the registration rollers are temporarily rotated in the reverse rotational direction which is opposite from the rotational direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction. Thereby, the print medium can be prevented from being nipped by the registration rollers when striking them. As a result, failure in correcting the inclination of the print medium can be reduced.

The controller may be configured to control the motor such that, after the print medium strikes the registration rollers and thereby forms the predetermined amount of slack in the print medium and before the motor drives the registration rollers to start conveying the print medium, the motor temporarily rotates the registration rollers in a reverse rotational direction opposite from a direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction.

According to the above configuration, after the print medium strikes the registration rollers and thereby forms the predetermined amount of slack in the print medium and before the registration rollers start to convey the print medium, the registration rollers are temporarily rotated in the reverse rotational direction which are opposite from the rotational direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction. Thereby, in a case where a leading edge portion of the print medium is nipped by the registration rollers, the leading edge of the print medium can be released from the nipping and returned to the nip line. As a result, failure in correcting the inclination of the print medium can be reduced.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a diagram showing the overall configuration of a printing system according to an embodiment of the present invention.

FIG. **2** is a block diagram showing the configuration of a control system of the printing system according to the embodiment of the present invention.

FIG. **3** is a diagram showing a waveform of a controlled conveyance speed of registration rollers and a waveform of a controlled conveyance speed of external sheet feed rollers, in a case of one-side printing on a sheet from an external sheet feed device according to the embodiment of the present invention.

FIG. **4** is a diagram illustrating one cycle.

FIG. **5** is a diagram showing a waveform of the controlled conveyance speed of the registration rollers and a waveform of the controlled conveyance speed of the external sheet feed rollers, corresponding to part of FIG. **3**.

FIGS. **6**A to **6**F are diagrams illustrating how sheets are conveyed when the registration rollers are stopped and activated.

DETAILED DESCRIPTION

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

Description will be hereinbelow provided for an embodiment of the present invention by referring to the drawings. It should be noted that the same or similar parts and components throughout the drawings will be denoted by the same or similar reference signs, and that descriptions for such parts and components will be omitted or simplified. In addition, it should be noted that the drawings are schematic and therefore different from the actual ones.

FIG. **1** is a diagram showing the overall configuration of a printing system according to an embodiment of the present invention. FIG. **2** is a block diagram showing the configuration of a control system of the printing system. In the following description, front means a position where a user stands, the front side of the paper plane of FIG. **1**. Further, as shown in FIG. **1**, up, down, left, and right directions in the following description are up, down, left, and right as seen by the user.

Thick lines in FIG. **1** are conveyance routes along which a sheet P (print medium) is conveyed. Among the conveyance routes, a regular route RC is shown with a solid line, an reverse route RR is shown with a one-dot chain line, a sheet discharge route RD is a route shown with a broken line, and a sheet feed route RS is shown with a two-dot chain line. Upstream and downstream mentioned in the following description mean upstream and downstream of these conveyance routes.

As shown in FIGS. **1** and **2**, a printing system **1** according to this embodiment includes an external paper feed device **2** and a printing machine **3**.

The external paper feed device **2** is configured to feed the sheet P to the printing machine **3**, and is capable of holding a large amount of sheets P. The external paper feed device **2** is connected to the upstream side of the printing machine **3**. The external paper feed device **2** includes a paper feed tray **11**, a scraper roller **12**, a pickup roller **13**, multiple pairs of intermediate conveying rollers **14**, and a casing **15** configured to house or hold these parts.

The paper feed tray **11** is configured such that sheets P used for printing are stacked thereon. The paper feed tray **11** is placed in such a manner as to be partially exposed to the outside of the casing **15**. The paper feed tray **11** is configured such that it can be moved up and down by a motor (not shown).

The scraper roller **12** is configured to separate an uppermost one of the sheets P stacked on the paper feed tray **11** by coming into contact with the uppermost one of the stacked sheets P and rotating, and thereby feed the uppermost sheet P toward the pickup roller **13** (rightward). The scraper roller **12** is placed above a right end portion of the paper feed tray **11**. The scraper roller **12** is configured to follow the rotation of the pickup roller **13** by a drive-power transmission mechanism (not shown).

The pickup roller **13** picks up the sheet P between the pickup roller **13** and a separating plate (not shown) placed below the pickup roller **13**, and sends the sheet P to the right. The pickup roller **13** is placed adjacently on the right side of the scraper roller **12**. The pickup roller **13** is driven to rotate by a motor (not shown).

The intermediate conveying rollers **14** are configured to convey the sheet P picked up from the paper feed tray **11** by the scraper roller **12** and the pickup roller **13** to external paper feeding rollers **38** to be described later. The intermediate conveying rollers **14** are placed along the paper feed route RS. The intermediate conveying rollers **14** are driven to rotate by a motor (not shown).

The printing machine **3** is configured to print on the sheet P. The printing machine **3** includes a paper feeding unit **21**, a printing unit **22**, an upper-side conveying unit **23**, a paper discharging unit **24**, a reversing unit **25**, a controller **26**, and a casing **27** configured to house or hold these units. Note that the printing machine **3** may only include some parts of the paper feeding unit **21** (registration rollers **41**, a registration motor **42**, and a registration motor driver **43** to be described later) and the controller **26**.

The paper feeding unit **21** is configured to feed the sheet P to the printing unit **22**. The paper feeding unit **21** is provided inside the casing **27**. The paper feeding unit **21** includes multiple paper feed trays **31**, multiple scraper rollers **32**, multiple pickup rollers **33**, multiple pairs of vertical conveying rollers **34**, a pickup motor **35**, a pickup motor driver **36**, a pair of internal paper feeding rollers **37**, a pair of external paper feeding rollers **38**, a paper feed motor **39**, a paper feed motor driver **40**, a pair of registration rollers **41**, a registration motor **42**, a registration motor driver **43**, and a registration sensor **44**.

Each paper feed tray **31** is configured such that sheets P used for printing are stacked thereon. The paper feed trays **31** are placed inside the casing **27**, at a lower portion thereof.

Each scraper roller **32** is configured to separate an uppermost one of the sheets P stacked on the corresponding paper feed tray **31** by coming into contact with the uppermost sheet P and rotating, and feed the uppermost sheet P to the left. The scraper roller **32** is placed above a left end portion of the paper feed tray **31**. The scraper roller **32** is configured to follow the rotation of the pickup roller **33** by a drive-power transmission mechanism (not shown).

Each pickup roller **33** is configured to pick up the sheet P between the pickup roller **33** and a separating plate (not shown) placed under the pickup roller **33**, and feed the sheet P to the left. The pickup roller **33** is placed adjacently on the left side of the corresponding scraper roller **32**.

Each pair of vertical conveying rollers **34** is configured to convey the sheet P picked up from the paper feed tray **31** by the scraper roller **32** and the pickup roller **33** to the internal paper feeding rollers **37**. The pairs of vertical conveying rollers **34** are placed along the paper feed routes RS.

The pickup motor **35** is configured to rotate the multiple pickup rollers **33** and the multiple pairs of vertical conveying rollers **34**. As described earlier, when the pickup rollers **33** rotate, the scraper rollers **32** rotate, too. The pickup motor is configured to be capable of connecting to and disconnecting from each pickup roller **33** and each pair of vertical conveying roller **34** by a clutch (not shown). The pickup roller **33**, the scraper roller **32**, and the vertical conveying rollers **34** to be rotated by the pickup motor **35** are switched by the clutch.

The pickup motor driver **36** is configured to drive the pickup motor **35**.

The pair of internal paper feeding rollers **37** is configured to convey the sheet P conveyed by the vertical conveying rollers **34** to the registration rollers **41**.

The pair of external paper feeding rollers **38** is configured to convey the sheet P conveyed by the intermediate conveying rollers **14** of the external paper feed device **2**, to the registration rollers **41**.

The paper feed motor **39** is configured to rotate the internal paper feeding rollers **37** and the external paper feeding rollers **38**. The paper feed motor **39** is connected to the internal paper feeding rollers **37** and the external paper feeding rollers **38** via a one-way clutch (not shown). By this one-way clutch, the internal paper feeding rollers **37** are rotated when the paper feed motor **39** is driven in one of rotational directions, and the external paper feeding rollers **38** are rotated when the paper feed motor **39** is driven in the other rotational direction.

The paper feed motor driver **40** is configured to drive the paper feed motor **39**.

The pair of registration rollers **41** is configured to provide slack to the sheet P conveyed by the internal paper feeding rollers **37**, the external paper feeding rollers **38**, or paper re-feed rollers **63**, by stopping the sheet P, and thereafter convey the sheet P to the printing unit **22** while nipping the sheet P. The registration rollers **41** are placed on the regular route RC, near the merging point between the paper feed route RS and the reverse route RR.

The registration motor **42** is configured to rotate the registration rollers **41**. The rotational drive power of the registration motor **42** is transmitted to the registration rollers **41** by a transmission mechanism (not shown) including gears, a belt, and the like.

The registration motor driver **43** is configured to drive the registration motor **42**.

The registration sensor **44** is configured to detect the sheet P to be conveyed to the registration rollers **41**. The registration sensor **44** is placed near the upstream side of the registration rollers **41**. The registration sensor **44** is formed by an optical sensor having a light emitting element and a light receiving element.

The printing unit **22** is configured to print on the sheet P while conveying the sheet P. The printing unit **22** is placed downstream of the paper feeding unit **21**. The printing unit **22** includes a belt conveyer **51** and an inkjet head unit **52**.

The belt conveyer **51** is configured to suck and retain the sheet conveyed from the registration rollers **41** on a belt, and conveys the sheet P to the upper-side conveying unit **23**. The belt conveyer **51** is placed downstream of the registration rollers **41**. The belt conveyer **51** is driven by a motor (not shown).

The inkjet head unit **52** has multiple line-type inkjet heads (not shown) each having multiple nozzles arranged in a direction (a front-rear direction) substantially orthogonal to a conveyance direction of the sheet P. The inkjet head unit **52** is placed above the belt conveyer **51**. The inkjet head unit **52** is configured to print an image on the sheet P conveyed by the belt conveyer **51** by ejecting ink from the inkjet heads.

The upper-side conveying unit **23** is configured to convey the sheet P conveyed by the belt conveyer **51**, to the right and then to the left such that the sheet P makes a U-turn. The upper-side conveying unit **23** includes multiple pairs of upper-side conveying rollers **56**.

Each pair of upper-side conveying rollers **56** is configured to convey the sheet P while nipping the sheet P. The most downstream pair of the upper-side conveying rollers **56** is placed at the upstream portion of the reverse route RR. Other pairs of the upper-side conveying rollers **56** are arranged along the regular route RC between the printing unit **22** and the paper discharging unit **24**. The multiple pairs of the upper-side conveying rollers **56** are driven to rotate by multiple motors (not shown).

The paper discharging unit **24** is configured to discharge a printed sheet P. The paper discharging unit **24** includes a switcher **57**, a pair of paper discharging rollers **58**, and a paper receiving tray **59**.

The switcher **57** is configured to switch the conveyance route of the sheet P between the paper discharge route RD and the reverse route RR. The switcher **57** is placed at a branch point of the paper discharge route RD and the reverse route RR. The switcher **57** is driven by a solenoid (not shown).

The pair of paper discharging rollers **58** is configured to convey the sheet P led to the paper discharge route RD by the switcher **57** and discharge the sheet P to the paper receiving tray **59**. The paper discharging rollers **58** are placed on the paper discharge route RD, between the switcher **57** and the paper receiving tray **59**. The paper discharging rollers **58** are driven to rotate by a motor (not shown).

The paper receiving tray **59** is configured such that the discharged sheet P is stacked thereon. The paper receiving tray **59** is placed at a downstream end of the paper discharge route RD.

The reversing unit **25** is configured to, in double-sided printing, reverse the sheet P printed on one side thereof and convey the sheet P to the registration rollers **41**. The reversing unit **25** includes a pair of reversing rollers **61**, a switchback section **62**, a pair of paper re-feed rollers **63**, and a switch gate **64**.

The pair of reversing rollers **61** is configured to convey the sheet P conveyed by the upper-side conveying unit **23**, into the switchback section **62** temporarily and then convey the sheet P out of the switchback section **62** to the paper re-feed rollers **63**. The reversing rollers **61** are placed on the reverse route RR, between the most downstream pair of upper-side conveying rollers **56** and an entry side of the switchback section **62**. The reversing rollers **61** are driven to rotate by a motor (not shown).

The switchback section **62** is a space into which the reversing rollers **61** convey the sheet P temporarily. The switchback section **62** is formed under the paper receiving tray **59**. The switchback section **62** is open at a portion near the reversing rollers **61** in order for the sheet P to be conveyed thereinto.

The pair of paper re-feed rollers **63** is configured to convey the sheet P conveyed by the reversing rollers **61**, to the registration rollers **41**. The paper re-feed rollers **63** are placed on the reverse route RR, between the reversing rollers **61** and the registration rollers **41**. The paper re-feed rollers **63** are driven to rotate by a motor (not shown).

The switch gate **64** is configured to guide the sheet P conveyed by the upper-side conveying rollers **56**, to the reversing rollers **61**, and also to guide the sheet P conveyed by the reversing rollers **61** out of the switchback section **62**, to the paper re-feed rollers **63**. The switch gate **64** is placed near the center of three points: the most downstream pair of upper-side conveying rollers **56**, the reversing rollers **61**, and the paper re-feed rollers **63**.

The controller **26** is configured to control the operation of each unit of the printing machine **3**, and also to control the external paper feed device **2**. The controller **26** is configured including a CPU, a RAM, a ROM, a hard disk, and the like.

The controller **26** is configured to control paper feed as follows. Specifically, after the sheet P strikes the registration rollers **41** and thereby forms a predetermined amount of slack, the controller **26** causes the registration motor **42** to start rotating the registration rollers **41** to convey the sheet P. Then, the controller **26** controls the registration motor **42** such that the registration motor **42** stops the registration rollers **41** once the sheet P exits the registration rollers **41**. Here, in stopping the registration rollers **41**, the controller **26** controls

the registration motor **42** such that the registration motor **42** produces torque in a direction opposite from a direction in which the registration motor **42** rotates in conveying the sheet P.

Next, the operation of the printing system **1** is described.

Once the printing system **1** starts its printing operation, an unprinted sheet P is conveyed to the registration rollers **41** along the paper feed route RS from any one of the paper feed tray **11** of the external paper tray unit **2** and the multiple paper feed trays **31** of the paper feeding unit **21**, and is then conveyed to the printing unit **22** by the registration rollers **41**. In the printing unit **22**, the sheet P is printed with ink ejected from the inkjet head unit **52** while being conveyed by the belt conveyer **51**.

In one-sided printing, the sheet P printed on one side thereof is conveyed from the belt conveyer **51** to the upper-side conveying unit **23**, is conveyed by the upper-side conveying rollers **56** of the upper-side conveying unit **23**, and is thereafter led to the paper discharge route RD by the switcher **57**. After that, the sheet P is discharged to the paper receiving tray **59** by the paper discharging rollers **58**.

In double-sided printing, after being conveyed by the upper-side conveying rollers **56** of the upper-side conveying unit **23**, the sheet P printed on one side thereof is led to the reverse route RR by the switcher **57**. In the reversing unit **25**, the sheet P is led to the reversing rollers **61** by the switch gate **64**, and is conveyed into the switchback section **62** by the reversing rollers **61**. Then, the sheet P is conveyed out of the switchback section **62** by the reversing rollers **61** and is led to the paper re-feed rollers **63** by the switch gate **64**. The sheet P is then conveyed to the registration rollers **41** by the paper re-feed rollers **63**, and is sent to the printing unit **22** by the registration rollers **41**. Here, an unprinted side of the sheet P faces the inkjet head unit **52** since the sheet P has been reversed. The printing unit **22** prints the unprinted side of the sheet P with ink ejected from the inkjet head unit **52**, while conveying the sheet P with the belt conveyer **51**. The sheet P printed on both sides thereof is discharged to the paper receiving tray **59**, as is the case for the one-sided printing descried above.

In the printing system **1**, in printing multiple sheets, after a certain sheet P is fed, a succeeding sheet P is fed not after the preceding sheet P is printed and discharged, but before the preceding sheet P is discharged. In this way, the printing is performed successively at predetermined intervals. Thus, multiple sheets P are conveyed on the conveyance routes at the same time.

Moreover, in the double-sided printing, except for an adjustment period immediately after starting print and immediately before finishing print, an unprinted sheet P fed from the paper feeding unit **21** and a sheet P printed on its one side and re-fed from the reversing unit **25** are alternately sent to the printing unit **22**. Thereby, printing on one side of an unprinted sheet P and printing on the other side (an unprinted side) of a sheet P printed on its one side are performed alternately.

In feeding the sheet P in the printing operation described above, the registration rollers **41** are driven intermittently for sheets to convey. How the registration rollers **41** are driven is described below.

Here, a case is described of one-sided printing on a sheet P from the external paper feed device **2**. FIG. **3** is a diagram showing a waveform of a controlled conveyance speed of the registration rollers **41** and a waveform of a controlled conveyance speed of the external sheet feeding rollers **38**, in a case of one-sided printing on a sheet P from the external sheet feed unit **2**.

First, control of the conveyance speed of the external paper feeding rollers **38** is roughly described. As shown in FIG. **3**, to feed a first sheet P, the controller **26** activates the paper feed motor **39** and controls the driving of the paper feed motor **39** such that the conveyance speed of the external paper feeding rollers **38** equals a speed V**1** for receiving the sheet P from the intermediate conveying rollers **14**. Thereafter, when the registration sensor **44** detects the leading edge of the sheet P, the controller **26** decreases the conveyance speed of the external paper feeding rollers **38** to a speed V**2** for striking the sheet P against the registration rollers **41**. When the sheet P strikes the registration rollers **41** and forms a predetermined amount of slack, the controller **26** stops the external paper feeding rollers **38** by stopping the paper feed motor **39**.

After that, at time t1 at which rotation of the registration rollers **41** is started to convey the first sheet P, the controller **26** activates the paper feed motor **39** so that the external paper feeding rollers **38** start rotating. After the paper feed motor **39** is activated, the controller **26** increases the conveyance speed of the external paper feeding rollers **38** to a speed V**3** and then decreases it to a speed V**4** so that the external paper feeding rollers **38** may operate in synchronization with the registration rollers **41**. The external paper feeding rollers **38** assist the registration rollers **41** in conveying the sheet P, by operating in synchronization with the registration rollers **41**. This assisted operation allows the sheet P to be conveyed by the external paper feeding rollers **38** and the registration rollers **41** while maintaining its slack.

At a timing at which the first sheet P exits the external paper feeding rollers **38**, the controller **26** increases the conveyance speed of the external paper feeding rollers **38** to the receiving speed V**1** so that the external paper feeding rollers **38** can receive a second sheet P. Thereafter, as is the case for the first sheet P, when the registration sensor **44** detects the leading edge of the second sheet P, the controller **26** decreases the conveyance speed of the external paper feeding rollers **38** to the speed V**2** for striking the second sheet P against the registration rollers **41**. When the second sheet P strikes the registration rollers **41** and forms a predetermined amount of slack, the controller **26** stops the external paper feeding rollers **38** by stopping the paper feed motor **39**.

After that, at time t3 at which the registration rollers **41** start to rotate to convey the second sheet P, the controller **26** activates the paper feed motor **39** to start rotating the external paper feeding rollers **38**. After that, the controller **26** repeats control similar to what is described above.

Next, control of the conveyance speed of the registration rollers **41** is roughly described. As shown in a circle C**1** in FIG. **3**, the controller **26** causes the registration rollers **41** to reversely rotate temporarily twice before time t1.

In FIG. **3**, a negative conveyance speed indicates a conveyance speed of reverse rotation. Directions of the respective registration rollers **41** rotated to convey the sheet Pin the conveyance direction (rightward), i.e., to the printing unit **22** are normal rotational directions, and directions opposite to those are reverse rotational directions. The controller **26** rotates the registration rollers **41** in the normal rotational directions by causing the registration motor driver **43** to apply positive voltage to the registration motor **42**, and rotates the registration rollers **41** in the reverse rotational directions by causing the registration motor driver **43** to apply negative voltage to the registration motor **42**.

Out of the two temporary reverse rotations of the registration rollers **41** before time t1, the first one is an entry prevention operation. In the entry prevention operation, the registration rollers **41** are rotated in the reverse rotational directions so as to prevent the leading edge of the sheet P from going

beyond a nip line of the registration rollers **41** and entering the registration rollers **41** when striking the registration rollers **41**. The second temporary reverse rotation is a sheet return operation. In the sheet return operation, the registration rollers **41** are temporarily rotated in the reverse rotational directions, in case the leading edge of the sheet P is nipped by the registration rollers **41**, to release the sheet P from the nipping by returning the sheet P to the nip line.

At time t1, the controller **26** activates the registration motor **42** to rotate the registration rollers **41** in the normal rotation directions. After activating the registration motor **42**, the controller **26** increases the conveyance speed of the registration rollers **41** to the speed V**3**. After that, the controller **26** decreases the speed for conveying the sheet P to the speed V**4** for sending the sheet P to the belt conveyer **51**.

Then, at time t2 which is a timing for starting control of stopping the registration rollers **41**, the controller **26** starts control of stopping the registration rollers **41**. In this stop control, the controller **26** controls the driving of the registration motor **42** so that the registration motor **42** temporarily generates reverse-rotational torque to rotate the registration rollers **41** in the reverse rotational direction. Thick solid lines in FIGS. **3** and **5** are set values of the conveyance speeds. When the registration motor **42** is reversely rotated, the set value of the conveyance speed of the registration rollers **41** is a (negative) conveyance speed in the reverse rotation direction, as shown in a circle C**2**. In contrast, as will be described later, an actual conveyance speed of the registration rollers **41** changes as shown in FIG. **5** with a thick, broken line. In the stop control, the registration motor **42** generates reverse rotational torque so that the registration rollers **41** are stopped with a short period of time.

Thereafter, before time t3, as is the above-described case for before time t1, the controller **26** causes the registration rollers **41** to perform the entry prevention operation and the sheet return operation.

At time t3, to convey a second sheet P, the controller **26** activates the registration motor **42** so that the registration rollers **41** start rotating in the normal rotational directions. After that, the controller **26** repeats control similar to what is described above.

A conveyance schedule for the registration rollers **41** is determined such that one cycle period T is from when the registration rollers **41** are activated to convey a sheet P to when the registration rollers **41** are activated to convey a succeeding sheet P (time t1 to time t3 in FIG. **3**).

One cycle period T corresponds to a one-cycle conveyance time of the belt conveyer **51**. As shown in FIG. **4**, one cycle consists of one sheet P and one inter-sheet portion adjacent thereto. As shown in FIG. **4**, one cycle period T is represented by the following formula (1) where Lp is the length of a sheet P in the conveyance direction, Lg is the inter-sheet portion, and A is the conveyance speed of the belt conveyer **51**.

$$T=(Lp+Lg)/A \quad (1)$$

Next, a detailed description is given of control of the conveyance speed in stopping and activating the registration rollers **41**. FIG. **5** is a diagram showing a waveform of the controlled conveyance speed of the registration rollers **41** and a waveform of the controlled conveyance speed of the external paper feeding rollers **38**, the diagram corresponding to part of FIG. **3**. FIGS. **6**A to **6**F are diagrams illustrating how sheets P are conveyed when the registration rollers **41** are stopped and activated.

At time t11 in FIG. **5**, as shown in FIG. **6**A, the registration rollers **41** are conveying a preceding sheet P, and the external paper feeding rollers **38** are conveying a succeeding sheet P. The registration rollers **41** are conveying the sheet P at the speed V**4** for sending the sheet P to the belt conveyer **51**. The registration rollers **38** are conveying the sheet P at the speed V**1** for receiving the sheet P from the intermediate conveying rollers **14**. Time t11 is right before time t12 (corresponding to time t2 in FIG. **3**) which is a timing for starting the stop control of the registration rollers **41**. Time t12 is a time predetermined by schedule as a time when the tailing edge of the sheet P exits the registration rollers **41**.

When the tailing edge of the sheet P exits the registration rollers **41** at timing t12 as shown in FIG. **6**B, the controller **26** performs the stop control of the registration rollers **41**. In this stop control, as described earlier, the controller **26** controls the driving of the registration motor **42** such that the registration motor **42** temporarily generates reverse-rotational torque. Specifically, the controller **26** temporarily applies negative voltage to the registration motor **42**, and then returns the voltage to zero.

By this stop control, the actual operation (conveyance speed) of the registration rollers **41** is as shown in FIG. **5** with the thick, broken line, and the registration rollers **41** can be stopped (the conveyance speed thereof can be reduced to zero) with a short period of time from time t12.

Although the conveyance speed of the registration rollers in the normal rotational directions is decreased monotonically to zero in the example shown in FIG. **5** with the thick, broken line, they may be temporarily reversely rotated.

If short-circuit brake control is performed on the registration motor **42** instead of the stop control described above, a period of time required from the stop control start timing to when the registration rollers **41** actually stop is longer than that in the case of the stop control described above, as shown in FIG. **5** with a thick, one-dot chain line. This is because, even if the short-circuit brake control is performed on the registration motor **42**, the registration rollers **41** continue to rotate in the normal rotational directions due to influences, such as inertia or load, of a transmission mechanism from the motor shaft of the registration motor **42** to the registration rollers **41**, and require a certain amount of time before stopping. In the stop control of this embodiment, the rotation of the registration rollers **41** in the normal rotational directions can be stopped quickly by the registration motor **42** generating reverse-rotational torque. This shortens the time from the stop control start timing to when the registration rollers **41** stop.

When the leading edge of the succeeding sheet P is detected by the registration sensor **44** as shown in FIG. **6**C, the controller **26** starts to speeds down the external paper feeding rollers **38** at time t13. Then, the controller **26** decreases the conveyance direction of the external paper feeding rollers **38** to the speed V**2** for striking the sheet P against the registration rollers **41**. At time t14 when the external paper feeding rollers **38** are driven at the striking speed V**2**, the sheet P strikes the registration rollers **41** at the striking speed V**2**.

From this time t14, for the entry prevention operation, the controller **26** temporarily applies negative voltage to the registration motor **42** so that the registration rollers **41** temporarily rotate in the reverse rotational directions. Thereby, as shown in FIG. **6**D, the registration rollers **41** temporarily rotate in the reverse rotational directions when the sheet P strikes the registration rollers **41**.

When the sheet P strikes the stopped registration rollers **41**, the registration rollers **41** might rotate in the normal rotational directions by being pushed by the sheet P. Thereby, the leading edge of the sheet P may go beyond the nip line of the registration rollers **41**, enter the registration rollers **41**, and be nipped by them. In this event, if the sheet P enters the regis-

tration rollers **41** with the sheet P inclined and is nipped in that state, the inclination cannot be corrected sufficiently. In this embodiment, as described above, the registration rollers **41** are temporarily rotated in the reverse rotational directions when the sheet P strikes the registration rollers **41**, to thereby prevent the leading edge of the sheet P from being nipped by the registration rollers **41**.

After the sheet P strikes the registration rollers **41**, the controller **26** stops the external paper feeding rollers **38** at time t15. By the rotation of the external paper feeding rollers **38** from time t14 to time t15, the sheet P forms a predetermined amount of slack. The timing for stopping the external paper feeding rollers **38** is predetermined according to schedule.

Once the predetermined amount of slack is formed in the sheet P, the controller **26** causes the registration rollers **41** to perform the sheet return operation before timing t16 (corresponding to time t3 in FIG. **3**) which is timing for activating the registration rollers **41**. Specifically, the controller **26** causes the registration motor driver **43** to temporarily apply negative voltage to the registration motor **42**. Thereby, as shown in FIG. **6**E, the registration rollers **41** are temporarily rotated in the reverse rotational directions. As a result, in a case where the leading edge portion of the sheet P is nipped by the registration rollers **41**, the leading edge of the sheet P can be released from the nipping and returned to the nip line.

Thereafter, at time t16, the controller **26** activates the registration motor **42** and the paper feed motor **39** to start rotating the registration rollers **41** and the external paper feeding rollers **38** in their normal rotational directions. Thereby, as shown in FIG. **6**F, the registration rollers **41** and the external paper feeding rollers **38** convey the sheet P while maintaining the slack thereof.

As described above, when stopping the registration rollers **41**, the controller **26** of the printing machine **3** performs control such that the registration motor **42** generates reverse-rotational torque. This can shorten the time from the stop control start timing to when the registration rollers **41** stop. Thus, a time period Ta (see FIG. **5**) can be shortened, the time period Ta being from the stop control start timing (time t12) to the timing at which the sheet P strikes the registration rollers **41** (timing t14). Here, a time period Tb from time t14 to time t16 in FIG. **5** is a period of time for forming slack of the sheet P and for preparing for paper feed, and a time period To from time t12 to time t16 is a period of time corresponding to the inter-sheet portion. Thus, decreasing the time period Ta can reduce the interval between the sheets in printing of multiple sheets. As a result, the productivity of the printing machine **3** can be improved.

Further, in the printing machine **3**, the registration rollers **41** perform the entry prevention operation. Specifically, from the timing when the sheet P strikes the registration rollers **41**, the controller **26** temporarily rotates the registration rollers **41** in the reverse rotational directions. This can prevent the sheet P from being nipped by the registration rollers **41** when striking the registration rollers **41**. As a result, failure in the correction of the inclination of the sheet P can be reduced.

Further, in the printing machine **3**, the registration rollers **41** perform the sheet return operation. Specifically, when the sheet P strikes the registration rollers **41** to form a predetermined amount of slack in the sheet P, the controller **26** temporarily rotates the registration rollers **41** in the reverse rotational directions before starting to rotate the registration rollers **41** in the normal rotational directions. Thereby, in a case where the leading edge portion of the sheet P is nipped by the registration rollers **41**, the leading edge of the sheet P can be released from the nipping and returned to the nip line. As a result, failure in the correction of the inclination of the sheet P can be reduced.

Note that at least any one of the entry prevention operation and the sheet return operation of the registration rollers **41** may be omitted. For example, the entry prevention operation and the sheet return operation may be omitted for a non-elastic sheet which is less likely to enter the registration rollers **41**, and performed only for an elastic sheet such as a cardboard.

Although a case of one-sided printing on a sheet P from the external paper feed device **2** is described in this embodiment, similar control of the driving of the registration motor **42** may be performed for one-sided printing on a sheet P from any of the paper feed trays **31** provided inside the printing machine **3**. The same applies to double-sided printing.

Embodiments of the present invention have been described above. However, the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

Moreover, the effects described in the embodiments of the present invention are only a list of optimum effects achieved by the present invention. Hence, the effects of the present invention are not limited to those described in the embodiment of the present invention.

What is claimed is:

1. A conveyance apparatus comprising:

a pair of registration rollers configured to convey a print medium to a printing unit of a printing machine in a conveyance direction;

a motor configured to rotate the registration rollers; and

a controller configured to control the motor such that

after the print medium strikes the registration rollers and thereby forms a predetermined amount of slack in the print medium, the motor starts rotating the registration rollers to convey the print medium, and

the motor stops rotating the registration rollers once the print medium exits the registration rollers,

wherein, in stopping rotating the registration rollers, the controller is configured to drive the motor to generate torque in a reverse rotational direction opposite from a rotational direction in which the motor generates torque to convey the print medium in the conveyance direction, and

the controller is configured to control the motor such that, at a timing time when the print medium strikes the registration rollers, the motor temporarily rotates the registration rollers in a reverse rotational direction opposite from a rotational direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction, thereby preventing passage of the print medium through the print rollers.

2. The conveyance apparatus according to claim **1**, wherein the controller is configured to control the motor such that, after the print medium strikes the registration rollers and thereby forms the predetermined amount of slack in the print medium and before the motor drives the registration rollers to start conveying the print medium, the motor temporarily rotates the registration rollers in a reverse rotational direction

opposite from a rotational direction in which the registration rollers are rotated in conveying the print medium in the conveyance direction.

3. The conveyance apparatus according to claim **1**, wherein, after the motor rotates the registration rollers in the reverse rotational direction to prevent passage of the print medium through the registration rollers, the controller controls the motor to temporarily rotate the registration rollers in the reverse rotational direction, thereby releasing a leading edge portion of the sheet from being nipped by the registration rollers and returning the leading edge portion of the sheet to a nip line of the registration rollers.

4. The conveyance apparatus according to claim **3**, further comprising a pair of paper feeding rollers, wherein the conveyance speed of the paper feeding rollers is different during the stopping of the registration rollers, and during the temporary rotation of the registration rollers in the reverse direction of rotation to prevent passage of the print medium through the print rollers.

5. The conveyance apparatus according to claim **1**, wherein the controller controls the motor to stop the registration rollers and generate torque in the reverse direction at a time that the print medium exits the registration rollers.

6. The conveyance apparatus according to claim **1**, wherein the controller controls the motor to temporarily rotate the registration rollers in the reverse direction at a time that the print medium strikes the registration rollers.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

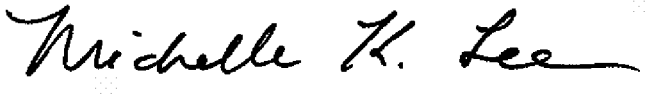
PATENT NO. : 9,126,791 B2
APPLICATION NO. : 14/098671
DATED : September 8, 2015
INVENTOR(S) : Inoue

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 12, line 54 (claim 1, line 20) please change "a timing time" to -- a time --.

Signed and Sealed this
Fifteenth Day of March, 2016



Michelle K. Lee
Director of the United States Patent and Trademark Office